CHAPTER 6

GEOLOGY

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CHAPTER 6: GEOLOGY

6.1 SCOPE

This chapter presents discussion of geologic conditions within and adjacent to the permit area, which consists of lease areas SL 062648 and U 054762.

6.2 METHODOLOGY

Conclusions herein are based on field Reconnaissance, exploratory drilling, and previous documentation.

6.3 REGIONAL GEOLOGIC FRAMEWORK

The Wasatch Plateau consists of Tertiary and Cretaceous strata, mostly limestone, sandstone, and shale that differ in resistance to erosion (Davis and Doelling, 1977). Limestones and sandstones generally form cliffs, whereas the shales form recessive slopes.

Stratigraphic units present in the vicinity of the Crandall Canyon area include from youngest to oldest (1) the North Horn Formation (slope-forming mudstone and sandstone), (2) the Price River Formation which consists of the basal Castlegate Sandstone Member (cliff-forming sandstones, conglomerates and minor amounts of shale of deltaic in origin) and the Upper Price River Member (steep slope-forming sandstone with minor interbeds of pebble conglomerate and shale of fluvial origin), (3) the Blackhawk Formation (cliff-forming sandstone underlain by slope-forming mudstone, shale and coal of paludal origin), (4) the Star Point Sandstone (cliff-forming sandstones consisting of deltaic and beach deposits), and (5) the Masuk Shale Member of the Mancos Shale (slope-forming marine shales), refer to Items 6-3 and 6-4 and Plate 6-1. The Star Point Sandstone contains one or several shale tongues of the underlying Masuk Shale in the Wasatch Plateau region.

The stratigraphic record produced by these units indicates that deposition up through the Blackhawk Formation consisted mostly of fine-grained detritus under conditions of relatively quiet and uniform sedimentation (Davis and Doelling, 1977). An erosional disconformity exists at the top of the Blackhawk Formation which is overlain by coarse clastics of the Castlegate Sandstone. These coarse continental sediments suggest tectonic movement to the west and probably mark the onset of the Larimide orogeny (Davis and Doelling, 1977).

The Wasatch Plateau lies in a transition zone between the relatively stable Colorado Plateau to the east and the relatively complex and unstable Basin and Range province to the west (Davis and Doelling, 1977). Strata of the western Wasatch Plateau dip into a complexly faulted monocline, whereas strata on the east side have predominantly gentle dips and faults are less numerous (Davis and Doelling, 1977).

Major faults present within the region of the coal fields are north-trending with maximum displacements of up to 2,300 feet (Davis and Doelling, 1977). Many north-trending faults with minor displacements are present and few east-trending faults, most of which have displacements of less than 100 feet, are also present locally.

Most of the strata in the coal field form broad anticlines and synclines that trend northeast or are roughly perpendicular to the principal fault zones (Davis and Doelling, 1977).

6.4 GEOLOGY OF PROJECT VICINITY

The drainage basin of Crandall Canyon covers approximately 5.7 square miles and exposes six geologic units, which range in age from Cretaceous to Tertiary. Surface lands within the permit area consist entirely of outcrop exposures of sandstones, mudrocks and coal of the Castlegate Sandstone, Blackhawk Formation, Star Point Sandstone and Price River Formation and are shown on Figure 7-1.

The Hiawatha and Blind Canyon coal seams, which will be of importance in the permit area are present at or near the base of the Blackhawk formation (Campanian in age). Several other thin lenticular coal seams are present at the property, but none are of significant thickness or of probable lateral extent to be of any economic interest. Only the Hiawatha seam is of sufficient thickness to be economically recoverable.

The Hiawatha coal seam has been mined and is exposed at an approximate elevation of 7900 feet amsl, refer to Item 6-1. Mining overburden above the Hiawatha coal seam in the permit area consists of the Blackhawk Formation, Castlegate Sandstone, and the Upper Price River Member. Surface outcrop of these formations rises from approximately 7900 feet (amsl) to approximately 9600 feet at the northwest corner of lease area U 054762. This results in a maximum overburden of approximately 1700 feet with an average overburden of approximately 700 to 800 feet. The entire area is underlain by the Star Point Sandstone.

Geologic inspection of the property indicates that prior mining of the Hiawatha Seam did not encounter subsurface water. The maps submitted as Items 6-3 and 6-4 and Plate 6-1 are

to the mine permit area and are not intended to clearly define the geologic formations in the area as the Hiawatha seam is entirely covered by rock units of the Blackhawk Formation as well as by the Price River Formation within the lease areas. Due to erosion, no other geologic formations which lie stratigraphically above the Price River Formation are present within the mine area.

Analysis of coal samples collected from the Hiawatha Seam indicate that it is a high volatile bituminous coal with a BTU content ranging form 12,500 to 13,000 BTU's, ash content of 6% to 8%, moisture of 3% to 5%, volatile matter from 40% to 44%, fixed carbon from 43% to 46% and sulfur from 0.3% to 0.8%. Forms of Sulfur average 0.20% pyritic sulfur, 0.09% sulfate sulfur, and 0.50% organic sulfur.

Additional technical information has been submitted to determine the nature, depth and thickness of the coal seams, rider seams, overburden and interburden strata for the permitted mine area based upon drilling completed in 1985 (refer to Items 6-1 and 6-5 and Plates 3-2 and 3-3). There is insufficient evidence to support the presence of the Blind Canyon Seam in Crandall Canyon, but further to the south, it thickens southward to the Mill Fork area, beyond which it again is of little value (Doelling, 1972, p.189). The old workings can provide information on the lower seam (Hiawatha) and some ground water information but nothing about the other seams. Additional geologic information was submitted by Mr. Wollen which contained specific lithologic characterizations of the interburden, and the strata immediately above and below the coal seams, refer to Items 6-1, Items 6-2. Items 6-3 and 6-4 were obtained from Doelling (1972) for additional regional information.

6.4.1 STRATIGRAPHY

The Blackhawk formation is comprised of approximately 1000 feet of gray, carbonaceous shales, siltstones, coals and thin interbedded sandstones. The coal beds to be mined near the base of the formation are 6 to 14 feet thick and are generally classified as a high volatile bituminous coal with a sulfur content of 0.30% to 1.00%. The blackhawk formation is underlain by the massive, cliff forming Star Point Sandstone which is 200 to 400 feet thick.

An accurate stratigraphic section based on the work of Doelling which has been confirmed by field analysis of distances between the minable coal seams and the thickness of overburden in the mine area. Item 6-1 includes two stratigraphic sections which were obtained by traversing the stratigraphic column from Crandall Creek to the Castle Gate Sandstone. The entire stratigraphic column is shown in Item 6-1 for the permit area as only the Blackhawk Formation exists as overburden in the southern

part of the permit area (formerly called Tract 1). The stratigraphic section accompanies this chapter as part of Item 6-4.

A coal isopach and overburden isopach map showing the depth to the mineable Hiawatha Seam is included as Plate 6-2 to support extrapolation of ground water hydrology projections from nearby mines to the Crandall Canyon Mine and to support projections of subsidence.

See section 6.5.2.

6.4.2 STRUCTURE

Formations in the Wasatch Plateau of this general area gently dip 1-3 degrees westward off the west flank of the San Rafael swell. The regional structure altitude is broken by several north-south trending, high angle normal faults which offset the rocks from less than 10 feet to approximately 250 feet or more. The major faults as mapped indicate that there are no major faults present in the permit area. Springs are present in the upper reaches of the canyon near the Castlegate Sandstone-Blackhawk Formation contact. Several seeps of water have been noted in the Crandall Canyon area issuing from the Star Point Sandstone. A complete discussion of the springs and seeps encountered within the permit area is in Chapter 7.

Applicant has provided a structure map as Item 6-3.

6.5 GEOLOGY OF COAL BED AND ADJACENT UNITS

6.5.1 EXPLORATION AND DRILLING

Information based on field reconnaissance exploration was obtained from the southern half of lease area SL 062648 (87.22 acres). With no structural disturbances and information from previous mining, we feel we can qualify the reserves on the 87.22 acres. Economics eliminates drilling of such a small parcel for exploratory reasons. See map included as Item 6-4 within this chapter for outcrop information.

6.5.2 STRATIGRAPHY

The stratigraphy in the permit area and vicinity of the Crandall Canyon Mine consists of the Mesaverde group formations. The stratigraphy of the permit area is included within Section 7.1.2.1. Additional information is contained in the Mining and Reclamation Plan, Huntington Canyon No. 4, Mine Permit

Application submitted by Beaver Creek Coal Company -- Part 6.4.1 Stratigraphy, pages 6-4 through 6-10.

Applicant has included two lithologic, depth correlated sections to show thicknesses of interburden and coal from the Star Point Sandstone to the surface. These geologic sections are attached to this document following this chapter as Item 6-1. The lithofacies of the Blackhawk Formation in the vicinity of the mine area are shown in stratigraphic section within Item 6-1. These sections should provide sufficient technical information to determine the nature, depth and thickness of the coal seams, rider seams, overburden and interburden strata for the permit area. The thickness and extent of all formations in the area adjacent to the mine area are shown on Figure 7-1 with related discussion in Section 7.1.2.1.

The drilling results obtained during 1985 indicate the presence of the Blind Canyon seam although it is of unmineable thickness, refer to Items 6-1 and 6-5. The upper seam will be called the Blind Canyon Seam at the request of DOGM to simplify discussion. The same seam has been referred to as the "upper Hiawatha Seam" and the "lower Bear Canyon Seam" at various other locations. The USGS is satisfied that the upper seams are of uneconomic importance. Refer to Item 6-2.

The applicant feels that the cross sections submitted with this document will also satisfy the questions of coal recoverability, and roof and subsidence stability factors involving strata type and thickness.

6.5.3 STRUCTURE

Plates 3-2, 3-3 and 6-2 show strike and dip providing an average strike over the entire area where the coal outcrop data have been obtained. An average strike designation was necessary due to the severe erosional and geographic conditions of the area, which would make anything but an average or mean direction highly inaccurate. The determination of the dip was at several points and averaged for a mean determination.

The ground water hydrology and aquiferous potential of the formations present in Crandall Canyon permit area are discussed in detail in Chapter 7, Section 7.1.2.

Based on the above information concerning the formations and coal seams present in the Mesaverde group, and that the Mesaverde Group formations in Crandall Canyon, as described by Doelling (1972), and as described by applicant's field work, are as typical as found elsewhere. We believe the following information should be acceptable to DOGM as it relates to the hydrologic conditions of Genwal's permit area.

(1) Information presented in Section 7.1.2.2 indicates that the water table in the Star Point Sandstone is below the coal seams of the lower Blackhawk Formation. The flow of ground water in the formation is toward Huntington Creek.

(2) The Star Point Sandstone, which underlies the Hiawatha seam, is predominantly a light -gray massive sandstone with minor interbedded layers of shale and siltstone near its base (Doelling, 1972). In the vicinity of the mine, the Star Point Sandstone is 200-400 feet thick. The Star Point Sandstone serves as an important regional aquifer (Danielson et al., 1981), yielding water to several minor and some major springs where fractured and jointed.

(3) The Blackhawk formation, at the base of which the Hiawatha seam is located, could contain perched aquifers in the lenticular sandstones interbedded within the shales. The shales of the Blackhawk Formation are only slightly permeable; consequently, ground water within the formation is perched. The shales of the Blackhawk formation are bentonitic and swell when wet; therefore, faults and fractures in the Blackhawk tend to seal, limiting secondary permeability, refer to the exceptions itemized in Section 7.1.2.2 (SP-53 through SP-58).

If perched water is encountered from the Blackhawk Formation, due to drilling or from the strains associated with subsidence, it's vertical flow to deeper strata would be altered. Some perched aquifers releasing water under topographic conditions as springs, may be affected.

See 6.4.2 above.

6.5.4 DETAILED COLUMNS OF INTEREST AND CROSS SECTIONS

See Item 6-1 included with this chapter. Stratigraphic section A was taken at the portal area and stratigraphic section B was taken 500 feet east of the portal area, refer to Plate 6-2 for locations of A and B.

6.5.5 COAL RESERVES

Coal-seam data for lease area SL 062648 indicates that approximately 840,000 tons of coal are in place, of which 400,000 tons are recoverable. Lease area U 54762 contains approximately 2.5 million tons of coal in place, of which approximately 1.5 million tons are recoverable. Approximately 0.5 million tons will be left in place for final retreat leaving approximately one million tons mineable during advance.

The Hiawatha seam is the only seam in the mine plan area that is of mineable thickness. The Hiawatha seam averages 6 feet thick in lease area SL 062648.

The information obtained from both drill holes 1 and 2 show the Blind Canyon being approximately 59 and 40 inches thick, respectively, which makes this seam unmineable and of no economic value. The Blind Canyon is located approximately 40 to 60 feet above the Hiawatha seam. Refer to Plated 3-2 and 6-2 for locations. The Blind Canyon exists on approximately 60 acres of the property with an average height of 4 feet, this translates into approximately 418,000 tons of coal in place. This seam remains fairly continuous across the property.

Coal deposit and reserve information is required by 30 CFR 211.10 (c)(6)(i) which must conform with the information submitted with the mining and reclamation plan. Revisions to the General Mining Order No. 1 has been submitted to the USGS as required.

6.5.5.1 Reserve Classifications

From USGS figures. A map is provided delineating coal outcrop lines form the Hiawatha and Blind Canyon seams with the strike and dip indicated at one point, refer to Plate 6-2.

6.5.5.2 Coal Quality and Characteristics, Sulfur Forms, Clay and Alkalinity

The pyrite, alkalinity and clay content information is from samples taken by applicant and submitted to Standard Laboratories, Huntington, Utah for chemical analysis. The lab reports are included with this document as Item 6-2.

The pyrite content and alkalinity content of the stratum immediately above the coal seams are as follows:

	Hiawatha	Blind Canyon
Pyrite	0.03%	0.09%
Alkalinity	7.6 - 63.3 mg/l	7.25 - 87.4 mg/l

The pyrite content, alkalinity and clay content of the stratum immediately below the coal seams are as follows:

	Hiawatha	Blind Canyon
Pyrite	0.06 %	0.07%
Alkalinity	3.95 - 4.0 mg/l	3.90 - 0.0 mg/l
Clay Content	9.5%	10.5%

The sulfur and iron sulfide content of the coal seams are as follows:

	Hiawatha	Blind Canyon
Sulfate	0.01	0.03
Organic	0.46	0.45
Pyritic	0.07	0.03

See 6.4 above.

6.5.6 ADJACENT UNITS (OVERBURDEN)

See 6.4 above.

6.5.6.1 Rock Characteristics, Acid-Toxic, Pyrite, Clay and Alkalinity

See 6.3, 6.4, 6.4.1 and 6.4.2 above.

6.6 GEOLOGIC EFFECTS ON MINING

6.6.1 MINING HAZARDS

Applicant determines there will be no mining hazards other than those normally encountered. Mining will be conducted with a MSHA approved roof and rib-control plan which will detail procedures under normal and adverse geologic conditions, (see map included as Plate 3-2 and 3-3 for extent of under ground workings).

6.6.2 SURFACE HAZARDS

Applicant determines there will be no surface hazards other than would normally encountered (negligible with underground operation).

6.6.3 IMPACTS OF MINING

Applicant determines there will be no geologic impacts as a result of proposed mining operation.

6.7 REFERENCES

Danielson, T.W., M.W. ReMillard, and R.H. Fuller. 1981. Hydrology of the Coal Resource Areas in the Upper Drainages of Huntington and Cottonwood Creeks, Central Utah. U.S. Geological Survey Water-Resources Investigations Open-File Report 81-539. Salt Lake City, Utah.

Davis, F.D. and H.H. Doelling. 1977. Coal Drilling at Trail Mountain, North Horn Mountain, Johns Peak Areas, Wasatch Plateau, Utah. Utah Geological and Mineral Survey Bulletin 112. Salt Lake City, Utah.

Doelling, H.H. 1972. Central Utah Coal Fields: Sevier-Sanpete, Wasatch Plateau, Book Cliffs, and Emery. Utah Geological and Mineral Survey Monograph Series No. 3. Salt Lake City, Utah.